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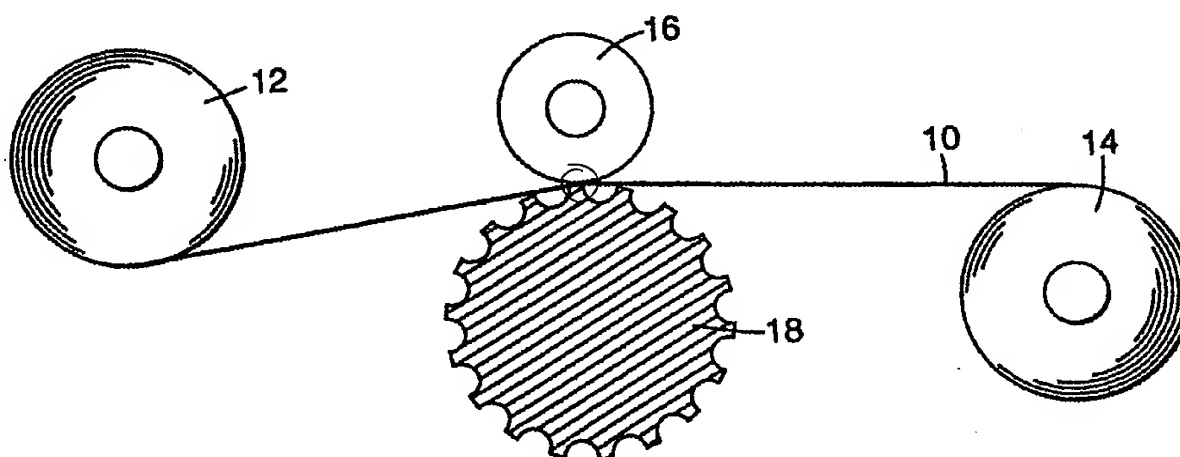
(57) Abstract

    A method of high speed bonding at least one material includes applying acoustic energy, using an acoustic horn and an anvil, to the material. The method also includes applying force to at least one of the horn and the anvil to yield a peak pressure between the horn and the anvil of at least 2.068×10^7 N/m^2. The acoustic energy and pressure are applied for a time sufficient to create bonds in the material such that the material is sufficiently quenched before reducing the pressure. The method can include applying acoustic energy at an amplitude of vibration selected in combination with the frequency of vibration to yield an acoustic velocity of no greater than 4.72 m/s.

ULTRASONIC BONDING METHOD

TECHNICAL FIELD

The present invention relates to ultrasonic bonding. More particularly, the present invention relates to ultrasonic bonding at high speeds.

BACKGROUND OF THE INVENTION

Ultrasonics is the science of the effects of sound vibrations beyond the limit of audible frequencies. The object of high power ultrasonic applications is to bring about some permanent physical change in the material treated. This process requires the flow of vibratory energy per unit of area or volume. Depending on the application, the resulting power density may range from less than a watt to thousands of watts per square centimeter. Although the original ultrasonic power devices operated at radio frequencies, today most operate at 20,000-69,000 Hz.

Ultrasonics is used in a wide variety of applications. For example, ultrasonics can be used for dust, smoke and mist precipitation; preparation of colloidal dispersions; cleaning of metal parts and fabrics; thermoplastic bonding; the formation of catalysts; the degassing and solidification of molten metals; metal welding; the extraction of flavor oils in brewing; electroplating; drilling hard materials; fluxless soldering; and nondestructive testing such as in diagnostic medicine.

Ultrasonic force is used to perforate sheet materials. U.S. Patent No. 3,966,519 discloses

perforating non-woven webs. The ultrasonic energy
amount is controlled by applying a fluid to the area
where the ultrasonic energy is applied. U.S. Patent
No. 3,949,127 discloses perforating non-woven webs by

5   applying intermittent ultrasonic fusion to the web and
then stretching the web to break the most intensely
fused regions causing perforations to form in the web.
U.S. Patent No. 5,269,981 discloses perforating a thin
nonporous film which requires applying a liquid to the

10   film before subjecting it to ultrasonic vibrations.
U.S. Patent No.5,735,984 discloses forming apertures in
an adhesive coated non-woven or foam sheet where the
height of the flattened raised areas on the anvil is
equal to or less than the thickness of the sheet

15   material and adhesive.

Ultrasonic forces are used in welding sheet
materials. U.S Patent No. 3,697,357 discloses welding
sheets made entirely or partially of thermoplastic
material or fiber by sealing an area of material. U.S.

20   Patent No. 3,939,033 discloses using ultrasonics to
simultaneously seal and cut thermoplastic textile
material. U.S. Patent No. 5,061,331 discloses an
ultrasonic cutting and edge sealing apparatus for
cutting and sealing semi-permeable and at least

25   partially thermoplastic fabric.

In acoustic bonding or welding, such as ultrasonic
welding, two parts to be joined (typically
thermoplastic parts) are placed directly below an
ultrasonic horn. In plunge bonding or welding, the

30   horn plunges (travels toward the parts) and transmits
ultrasonic vibrations into the top part. The
vibrations travel through the top part to the interface
of the two parts. Here, the vibrational energy is

converted to heat due to intermolecular friction that
melts and fuses the two parts. When the vibrations
stop, the two parts solidify under force, producing a
weld at the joining surface.

5   Continuous ultrasonic welding is typically used
for sealing fabrics, films, and other parts. In the
continuous mode, typically the ultrasonic horn is
stationary and the part is moved beneath it. Scan
welding is a type of continuous welding in which the
10   plastic part or web material is scanned beneath one or
more stationary horns. In rotary horn welding, a
rotating horn is used typically in conjunction with a
rotating anvil. In traverse welding, both the table
over which the parts pass and the part being welded
15   remain stationary with respect to each other while
moving underneath the horn or while the horn moves over
them.

           Many uses of ultrasonic energy for bonding and
cutting thermoplastic materials involve ultrasonic
20   horns. A horn is an acoustical tool usually having a
length of a multiple of one-half of the horn material
wavelength and made of, for example, aluminum,
titanium, or steel that transfers the mechanical
vibratory energy to the part. (Typically, these
25   materials have wavelengths of approximately 25 cm (10
in).) Horn displacement or amplitude is the peak-to-
peak movement of the horn face. The ratio of horn
output amplitude to the horn input amplitude is termed
gain. Gain is a function of the ratio of the mass of
30   the horn at the vibration input and output sections.
Generally, in horns, the direction of amplitude at the
face of the horn is coincident with the direction of
the applied mechanical vibrations.

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Traditionally, ultrasonic cutting and welding use
horns which vibrate axially against a rigid anvil, with
the material to be welded or cut being placed between
the horn and anvil. Alternatively, in continuous high
5   speed welding or cutting, the horn is stationary while
the anvil is rotated, and the part passes between the
horn and the anvil. In these cases, the linear
velocity of the part is matched with the tangential
velocity of the working surface of the rotating anvil.

10   However, drag between the part and the horn can
cause stress in and around the weld area during
welding. Additionally, closure or nip forces also
create stress in the bond area. These factors affect
the weld quality and strength which, in turn, limit the
15 line speeds.

One way to minimize these limitations is to shape
the working surface of the horn to attain a progressive
convergent or divergent gap depending upon the part.
This can reduce the stresses but does not eliminate the
20 drag stress. A carrier web can virtually eliminate
drag stress.

Another way to attain high quality and high speed
ultrasonic welds is to use a rotary horn with a
rotating anvil. This system can reduce or eliminate
25 the drag stress during the weld. Typically, a rotary
horn is cylindrical and rotates around an axis. The
input vibration is in the axial direction and the
output vibration is in the radial direction. The horn
and anvil can be two cylinders close to each other,
30 rotating in opposite directions with substantially
equal tangential velocities. The part to be bonded
passes between these cylindrical surfaces at a linear
velocity which equals the tangential velocity of these

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cylindrical surfaces. Matching the tangential
velocities of the horn and the anvil with the linear
velocity of the material can minimize the drag between
the horn and the material. The excitation in the axial

5   direction is similar to that in conventional plunge
welding.

U.S. Patent No. 5,096,532 describes two classes of
rotary horn. The patent compares a commercially
available rotary horn, manufactured by Mecasonic of

10   Annemasse France (Mecasonic horn) and a rotary horn
described in the '532 patent. The shape of the '532
horn differs from that of the Mecasonic horn; the '532
horn is solid, and the Mecasonic horn is a partially
hollowed cylinder.

15   The Mecasonic horn is a full wavelength horn. The
axial vibration excites the cylindrical bending mode to
provide the radial motion, and the mode of vibration
depends on Poisson's ratio. The radial motion of the
weld face is in phase with the excitation, and there

20   are two nodes for the axial motion, and two nodes for
radial motion. The '532 horn is a half wavelength
horn. The axial vibration provides the radial motion.
The mode of vibration is independent of Poisson's
ratio. The radial motion of the weld face is out of

25   phase with the excitation, and there is only one node,
at the geometric center of the weld face.

U.S. Patent No. 5,707,483 and U.S. Patent No.
5,645,681 describe novel rotary acoustic horns.

In known systems, welding is governed by the

30   various parameters which can be changed to alter the
welding process. These parameters include the
frequency, amplitude of vibration, the duration of
ultrasonic exposure, temperature (which is a function

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of the frequency), and the pressure between the horn
and the anvil.

To properly weld materials, it is necessary to
raise the interfacial temperature of the item being

5   welded to allow the operation, such as bonding, to
occur. It is also necessary to quench it and reduce
the temperature rapidly, after the weld is made, to
prevent stress from damaging the bonded area while the
bond is still warm. The speed at which the temperature

10 can be increased and decreased is often the limiting
factor in the speed of welding.

SUMMARY OF THE INVENTION

The invention is a method of high speed bonding at

15 least one material including at least one thermoplastic
component. The method includes applying acoustic
energy, using an acoustic horn and an anvil, to the
material. The method also includes applying force to
at least one of the horn and the anvil to yield a peak

20 pressure between the horn and the anvil of at least
2.068×10^7 N/m^2. The acoustic energy and pressure are
applied for a time sufficient to create bonds within
the material such that the material is sufficiently
quenched before reducing the pressure.

25   The method can include applying acoustic energy at
an amplitude of vibration selected in combination with
the frequency of vibration to yield an acoustic
velocity of no greater than 4.72 m/s.

The acoustic energy and pressure can be applied

30 for a time sufficient to create bonds in the material
such that the material is sufficiently quenched before
reducing the pressure. Thermoplastic peak temperatures
are reached such that sufficient heating occurs to

create acceptable bond strength and the bond area is cooled adequately and in sufficient time to prevent internal and external stresses from adversely affecting bond quality and to prevent bond degradation such as

5   holes or cut edges.

The peak pressure could be at least 3.448×10^7 N/m^2, or at least 6.895×10^7 N/m^2. The total basis weight of the laminates can be at least 200 gm/m^2. The acoustic energy can be at a frequency of at least

10   10,000 Hz, and can be from 14,000 Hz through 32,000 Hz. The acoustic velocity can be no greater than 3.15 m/s.

The method can include continuous welding or plunge welding and the materials can move past the acoustic horn at speeds of more than 30 cm/min.

15   The material can include woven layers; films; non-wovens; and non-thermoplastic materials which includes at least one of a cotton-based material and a paper-based material.

The anvil dimensions can be selected in

20   combination with the properties of the material being bonded, the amplitude of the applied acoustic energy, the pressure on the anvil, and the thermal conductivities of the horn and anvil.

25   BRIEF DESCRIPTION OF THE DRAWINGS

The Figure is a side view of patterned rotating anvil with a rotary horn.

DETAILED DESCRIPTION

30   The invention is a method of rapidly bonding (also called welding) materials using acoustic energy using acoustic horns and anvils. In its simplest form, a material 10 passes from an unwind roll 12 to a winder

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roll 14 between a horn 16 and an anvil 18. As shown in
the Figure, both the horn 16 and the anvil 18 rotate.
The anvil 18 is patterned.

The horn can operate at various frequencies such
5 as those above 10,000 Hz. The horn can be an
ultrasonic horn operating at frequencies at or above
20,000 Hz. This method can be used to bond materials
which can have low or high loft. (Bonding includes
reinforcing, laminating, joining.) Laminates refers to
10 flexible web-type materials and can include two or more
layers. Materials which have at least one
thermoplastic layer where the total basis weight of the
material is at least 200 gm/m^2 can be bonded (as can
less massive materials). The method can be used on
15 laminates including thermoplastic and non-thermoplastic
combinations, such as non-wovens, wovens, films,
papers, and cottons.

The method can include applying acoustic energy to
the materials at relatively low amplitudes and creating
20 a pressure between the horn and the anvil that is
relatively high. A key is the use of very high weld
pressures typically in combination with amplitudes that
are lower than would typically be used for high speed
bonding of high basis weight materials.

25 The amplitude of vibration and the applied
frequency are related; the resulting transfer of energy
for a low amplitude and high frequency can be the same
as that for a relatively high amplitude and relatively
low frequency. These parameters are proportional.
30 That is, increasing the amplitude and decreasing the
frequency can yield the same heating.

The rate of transfer of energy from acoustic waves
depends on the square of the amplitude and the square

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of the angular frequency. Because the ultrasonic
velocity is the amplitude times the angular frequency,
the rate of energy transfer is dependent on the square
of the ultrasonic velocity. (The rate of viscoelastic
5   heating in a polymer is proportional to the angular
frequency times the square of the amplitude.) Thus,
the rate of energy transfer can be the same if one uses
twice the frequency but half the amplitude. For
example, for an amplitude that is 75 microns peak-to-
10   peak and a frequency of 20,000 Hz, the peak amplitude
is 37.5 microns. The angular frequency is 2π times
20,000 Hz. The ultrasonic velocity is therefore:

$$(37.5 \times 10^{-6} \text{ m}) 2\pi (20,000 \text{ Hz}) = 4.71 \text{ m/s}$$

Throughout the remainder of this specification, the
15   amplitude values are those for systems operating at a
frequency of 20,000 Hz. The required amplitude
decreases with higher frequencies. The equivalent
amplitudes to arrive at the same ultrasonic velocities
for other frequency systems can be obtained by
20   multiplying the listed amplitudes by the ratio of
20,000 Hz (the frequency used to obtain the listed
amplitudes) and the frequency of interest.

For ultrasonic frequencies of vibration of 20,000
Hz, the method can include applying acoustic energy to
25   the materials at an amplitude of vibration no greater
than 75 microns peak-to-peak. Amplitudes of no greater
than 50 microns peak-to-peak can be used. These
amplitudes are less than those conventionally used,
which are typically 75 to 100 microns or more even for
30   lower speed continuous bonding.

The method also includes applying a force to at
least one of the horn and the anvil to yield an average
pressure between the horn and the anvil of at least

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2.068 x 10^7 N/m^2 (3,000 psi). This pressure is high, and in many instances can be greater than 1.379 x 10^8 N/m^2 (20,000 psi). These pressures are much more than those currently used, which typically are from 6.895 x

5   10^5 N/m^2 (100 psi) to 6.895 x 10^6 N/m^2 (1000 psi). The force can be created using known methods including pneumatics, hydraulics, mass and gravity, springs, material expansion (such as by piezoelectric or thermal) or by setting a fixed gap between the horn and

10   anvil.

The pressure between the horn and anvil is determined by dividing the force applied to the horn or anvil by the area of the weld site(s) where the material is in contact with the horn and anvil. For

15   plunge welding, dividing the applied force by the weld area in contact between the horn and anvil yields a pressure that is an average over the weld area for that weld (the mechanical alignment variation or welding rate variation of particular weld locations in the weld

20   area can give rise to locally higher or lower forces). Additionally, the applied force can vary during welding. The force for the calculation is the highest force that is applied during the part of the weld cycle where the material is being welded.

25   For continuous welding, the area is the area of the material in contact with the weld sites between the horn and anvil on the upweb side of the weld nip. This area is the length of the material times the width of the weld sites. The average pressure then is

30   determined by applying the force between the horn and anvil, while keeping the horn, anvil, and material stationary. The horn is vibrated for the short time necessary to create a bond, and the surface area of the

resultant weld is measured. If the weld area includes
discrete weld pads, then the measured area is the
length of the pad times the width times the number of
pads bonded. This area measured is about twice the
5   actual area because during a continuous operation the
material leaving the weld nip has already been bonded
and is thinner; in the static weld test, the material
on both the input and output side of the nip is bonded.
The applied force is divided by half the measured weld
10   surface area to yield the average pressure. This is an
average pressure because the radius of a rotating anvil
creates a pressure profile on the material between the
horn and anvil as a function of the closure gap and the
weld state of the material as it progresses through the
15   nip.

The application of acoustic energy and pressure
occurs for a time sufficient to create bonds between
the adjacent layers of materials and to sufficiently
quench the materials before reducing the pressure. The
20   pressure reduction occurs when the material leaves the
weld nip area. The materials must reach thermoplastic
peak temperatures to yield sufficient polymer diffusion
for compatible materials or melting of at least one
polymer to create a bond to another material such as to
25   form a laminate. (This could be, for example,
polypropylene flowing into or around a non-melting
surface or fiber.) The heating needs to be sufficient
to yield diffusion bonding or movement of one material
around or into another material's surface to make a
30   mechanical surface bond. Yet the heating need not
actually melt the materials.

The bond area must be cooled adequately and
quickly before leaving the nip between the horn and the

anvil and before relieving the applied force to prevent
internal and external stresses from adversely affecting
bond quality such as by weakening of the bonds,
creating holes, or material melt back. Also, the
5   heating must be sufficiently localized to avoid
excessive temperatures at the transition line between
the melted or partially melted polymer at the joint and
the polymer adjacent to the bond area. The material is
not subjected to stresses which can adversely affect
10 the bond quality. Rapid heating without overheating
and rapid cooling reduces excessive temperatures in the
bond (or seal) and in the periphery of the bond. This
increases the strength of the weld and reduces bond
degradation such as excessively brittle bonds;
15 overheating at the edges of the bond; and hole
formation; it increases the ability of the bond to
withstand both internal and external stresses
immediately after bonding.

The inventors have found that despite the large
20 body of publicly available information about ultrasonic
bonding, there was still an unfilled need to improve
the bonding process and to bond at higher speeds. In
this method the particular parameters to be optimized
and the combinations of levels of each parameter solves
25 a long-felt, unmet need. The method combines very high
pressures with relatively low amplitudes of ultrasonic
vibration. These characteristics are selected within
relatively narrow and previously unknown process
windows which permit high speed continuous ultrasonic
30 bonding of web materials. These process windows can
also extended to plunge weld applications to improve
weld quality.

The method can be varied by optimizing various
parameters which can include: ultrasonic amplitude;
pressure; exposure time; material properties (such as
melt temperatures, absorption coefficients, melt
5   rheology, and thermal conductivities); heat losses
(such as by thermal conductivity) to the anvil, the
horn, carrier webs, surrounding polymers, absorptive
additives, and other locations; and weld geometries.
These parameters are selected in combination with each
10   other. Characteristics to vary include the properties
of the material being bonded, the amplitude of the
applied acoustic energy and the pressure between the
horn and anvil, and the thermal conductivities of the
horn and anvil. Anvil properties include its length,
15   width, edge radius, surface texture, and thermal
conductivity, and the dimensions of the weld sites on
the anvil, their orientation and spacing. The specific
method is to choose anvil dimensions, then optimize the
processing conditions using the material properties.
20   If they are suboptimal, then modify the anvil
dimensions. If subsequent iterations are unsuccessful,
then investigate material property alternatives.

It is known that weld strength and quality tend to
decrease with higher processing speeds and with
25   increases in the web loft and mass during high speed
continuous bonding of web-based materials. (Also, the
weld quality decreases with increases in the non-woven
material basis weight for plunge welding.) Tests by
the inventors have demonstrated that this problem
30   exists because the melted web layers do not become
adequately quenched before leaving the bonding nip.

In known methods of bonding high loft non-woven
materials at high speeds processing conditions are

changed to increase the rate of energy going into the
weld area, typically by increasing both the applied
force and the amplitude of vibration. However, this
results in poor·quality welds because before the
5   polymer melts to its final weld thickness, the
materials to be bonded are excessively warm and are
leaving the weld nip. In other words, the cause of the
poor quality welds is due to the inability of the
process, after the bond occurs, to remove the heat that
10   was required to bond the materials sufficiently fast.
Thus, as the welded sample exits from the weld nip, it
can retain excessive heat, resulting in weak and
distorted bonds (due to stress, strain, and shrinkage).

The inventors have found that by increasing the
15   pressure on the weld site by 5 to 50 times over typical
applications one creates a process that is a hybrid
between thermal and ultrasonic bonding. It has also
been shown to be beneficial for many materials, such as
lofty non-wovens, to reduce the weld amplitude by about
20   half of what would normally be desired. When working
with less lofty materials, such as woven materials or
film, reduced weld amplitude is not critical. Good
bonding can be attained by the application of acoustic
energy at high pressures without reducing amplitude.
25   The selection of amplitude is material dependent.

This process produces high quality welds and bonds
and can do so at relatively high speeds of more than 30
m/min (100 ft/min) with high basis weight materials.
These conditions also improve the bonding ability of
30   thinner constructions and allow higher web speeds to be
used. Non-woven bonding of 430 gm/m^2 materials has been
demonstrated at speeds of 120 m/min (400 ft/min).
Higher speeds are possible because this speed was

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limited by the capabilities of the equipment used, not the process itself. Typically, higher loft materials, higher web speeds, and lower amplitudes require higher bonding pressure.

5   Contrary to conventional wisdom, the high pressures and low amplitudes are sufficient to create a diffusion bond; the high pressure rapidly decreases the thickness at the weld site to limit the rate of energy input, to decrease the quantity of heat to be removed,

10 and to reduce the weld thickness to allow the thin weld area to more rapidly give up its heat to the horn and anvil (which serve as heat sinks).

    The higher pressures promote freezing of the thin weld area before excessive displacement of the material

15 from the weld site occurs and cuts the weld area or creates a too thin weld. This happens because the heat sinks are proportional to the surface area, and the heat input is proportional to the material mass and its absorption characteristics. As the material thins

20 quickly, the sinks remove heat faster than heat is input and the material freezes. Additional time or energy will not easily cause it to re-melt (because the cooler polymer absorbs less energy). Thus, the seal thickness and the floating gap between the horn and

25 anvil are a result of the material freezing before leaving top dead center area of the anvil. Additional lowering of the temperature also occurs just after top dead center, which reduces the temperature of the periphery of the weld. In other words, using very high

30 pressures and low amplitudes of vibration allows the melt of bonded materials to be quenched before leaving the welding nip.

Some cut and seal operations and some aperturing
operations require very high pressures between the horn
and anvil, and higher amplitudes. The goal of these
operations however is to not allow the materials to
5   freeze in the area where the cutting or aperturing
occurs. Thus, these processes differ from bonding in
that the freezing and quenching of material is not
desired, while in a bonding process it is necessary.

Various changes and modifications can be made in
10   the invention without departing from the scope or
spirit of the invention. For example, the method of
welding can be continuous welding or plunge welding.
The disclosures of all of the patents mentioned in this
specification are incorporated by reference.

15   A support, which can be located at the nodes,
allows the use of higher forces than are possible with
known horns. The support can be in sliding contact;
have a low friction, high PV plastic bearing surface
(that stands up to the forces and surface speeds used);
20   thin (so it loses its heat quickly to the support
structure); and have a thermally conductive (for
example, aluminum) support structure with cooling
passages. The support can be rigidly or compliantly
mounted and can be a block of aluminum with a concave
25   radius where the bearing material is. Alternatively,
multiple supports can rollingly contact the horn while
incorporating the thin polymer feature.

There is relative deflection between the horn and
the anvil as a thicker portion of the material enters
30   the nip. (The thicker portion can be created by
wrinkles, high loft areas, and high mass areas.) This
produces an inertial force (which acts as an additional
force to the applied force) which resists the relative

motion and can weld the thicker portion. The inertial force can help compensate for thicker areas in nonwoven materials. The magnitude of this inertial force can be altered by changing the mass of the horn, the anvil, or

5 both. Preferably the component that is floating and biased toward the other component is the member whose mass is changed. After the thicker section has passed the nip area, the force is less, and with the proper masses it does not become less than the pressures

10 required to bond the thinner material. Alternative systems to achieve the additional force could include dual stage springs; piezoelectric; or staged (progressive) pneumatic or hydraulic systems.

CLAIMS

1.   A method of high speed bonding at least one
material including at least one thermoplastic
5   component, the method comprising:
        applying acoustic energy, using an acoustic horn
and an anvil, to the material;
        applying force to at least one of the horn and the
anvil to yield a peak pressure between the horn and the
10   anvil of at least 2.068×10^7 N/m^2; and
        applying the acoustic energy and pressure for a
time sufficient to create bonds in the material such
that the material is sufficiently quenched before
reducing the pressure.

15

2.   The method of claim 1 wherein the step of
applying force comprises applying a pressure of at
least 6.895×10^7 N/m^2.

20   3.   A method of high speed bonding at least one
material including at least one thermoplastic
component, the method comprising:
        applying acoustic energy, using an acoustic horn
and an anvil, to the material at an amplitude of
25   vibration selected in combination with the frequency of
vibration to yield an acoustic velocity of no greater
than 4.72 m/s; and
        applying force to at least one of the horn and the
anvil to yield a peak pressure between the horn and the
30   anvil of at least 2.068×10^7 N/m^2.

4.   The method of any of claims 1 or 3 wherein
the total basis weight of the material is at least
200 gm/m^2.

5   5.   The method of claim 3 wherein the steps of
applying acoustic energy and applying pressure comprise
at least one of: (a) applying the acoustic energy and
pressure for a time sufficient to create bonds in the
material such that the material is sufficiently
10   quenched before reducing the pressure; (b) applying
acoustic energy and applying pressure comprise applying
the acoustic energy and pressure to reach thermoplastic
peak temperatures such that sufficient heating occurs
to create acceptable bond strength and the bond area is
15   cooled adequately and in sufficient time to prevent
internal and external stresses from adversely affecting
bond quality and to prevent bond degradation such as
holes or cut edges.

20   6.   The method of claim 3 wherein the step of
applying acoustic energy comprises applying acoustic
energy at a frequency of from 14,000 Hz through
32,000 Hz.

25   7.   The method of claim 3 wherein at least one
of: the step of applying acoustic energy comprises
applying acoustic energy at an amplitude of vibration
selected in combination with the frequency of vibration
to yield an acoustic velocity of no greater than
30   3.15 m/s; and the step of applying pressure comprises
applying a pressure of at least 6.895 x 10^7 N/m^2.

8.   The method of claim 1 wherein the step of
applying acoustic energy comprises at least one of
continuous and plunge welding.

9.   The method of claim 1 wherein at least one of
the components is one of a woven layer; a film; a non-
woven; and a non-thermoplastic material.

10.   The method of claim 1 wherein all of the
components are thermoplastic non-wovens.

11.   The method of claim 1 further comprising the
step of selecting the anvil dimensions in combination
with the properties of the material being bonded, the
amplitude of the applied acoustic energy and the
pressure on the anvil, and the thermal conductivities
of the horn and anvil.

12.   The method of claim 1 where the step of
applying force comprises choosing an appropriate mass
of at least one of the horn and anvil to compensate for
intermittent thickness variations of the incoming
material, by increasing the force using inertial
forces.
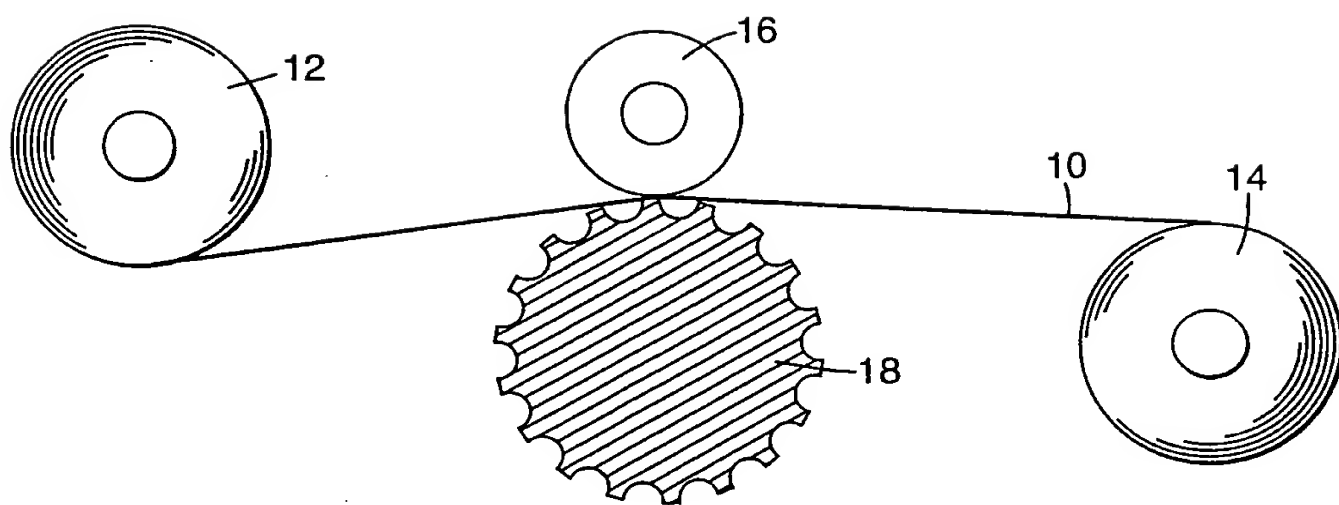
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   B23K20/10   B29C65/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   B23K   B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical. search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 457 187 A (KIMBERLY-CLARK CORPORATION) 21 November 1991 abstract see table 1	1,3,5-7, 9,11,12
A	FR 2 507 531 A (MECASONIC) 17 December 1982 see page 1, paragraph 1; figures 1,5	1,2
A	EP 0 894 612 A (KIMBERLY-CLARK CORPORATION) 3 February 1999 see table 1	1-12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 1999	27/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Herbreteau, D

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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